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Uncovered interest parity and risk premium convergence in Central and Eastern European countries ☆

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ABSTRACT

This study applies non-linear threshold unit-root test to investigate the non-stationary properties of the uncovered interest parity (UIP) with risk premium for ten Central and Eastern European (CEE) countries. We find that non-linear threshold unit-root test has higher power than linear method suggested by Caner and Hansen (2001) if the true data generating process of risk premium convergence is in fact a stationary non-liner process. We examine the validity of UIP from the non-linear point of view and provide robust evidence clearly indicating that UIP holds true for seven countries. Our findings point out that capital mobility and exchange market efficiency are in these CEE countries with non-linear way.

1. Introduction

The Central and Eastern European (CEE) countries have faced a serious transformation downturn followed by considerable economic growth. To catch up with European Union (EU) countries in economic growth is a natural goal for the relatively poor CEE countries, yet which at the beginning of the 1990s reached only 20–40% of Germany's per capita GDP. Although there has been some progress of the CEE countries in comparison to the EU member countries during the second half of 1990s, significant economic gap still exists and the average per capita income is still way less than that in EU member countries. As economic integration is an integral part of functions for the EU, many of the CEE countries have expressed their strong intention to join the European Monetary Union (EMU). In addition, the prospects of EU membership have also stimulated economic growth, as the political risk premium was sharply reduced and capital inflows started to rise in several CEE economies. The EU single market and financial market integration in particular reduce barriers to capital flows, which results in stronger links between the foreign exchange market and the interest rate market. Stronger links indicate that central banks must also take this aspect into account when making decisions in terms of interest rate and money supply, as these decisions can have undesirable/negative impacts on the whole financial market. Moreover, the idea of granting CEE countries membership in the EMU may disturb price stability when there is no convergence of its long-term interest rate to the average interest rate, so in order to realize the convergence, the CEE countries must adjust their monetary policies in the direction of the core of the EMU countries. Under the conditions of uncovered interest parity (UIP), long-term interest rate differentials are equal to expected exchange rate differentials across countries. Consequently, evidence of long-term interest rate convergence between CEE countries and the core of the EMU can be interpreted as long-run monetary policy convergence of the CEE countries to the EMU policies. Such knowledge has practical implications concerning the process of evaluating the preparedness of CEE countries to join the EMU.

Earlier empirical literature on the UIP condition mostly focuses on developed economies rather than emerging markets because of lack of data (Pasricha, 2006). Recently, increases in the degree of financial liberalization in emerging markets enabled many researchers to analyze foreign exchange market efficiency in these economies (Alper et al., 2007). The examination of UIP among CEE countries and other European transition countries has received considerable attention and has been studied from a variety of approaches. Unfortunately, due to different approaches and spans thus far none has been proven to be conclusive. Flood and Rose (1996) use the UIP test to examine European currencies in both fixed and flexible exchange rate regimes and they find that a large amount of the forward puzzle vanishes for fixed currency regimes. Choudry (1999) investigates forward market efficiency using UIP, and finds that there is no forward puzzle in at least some cases. Bansal and Dahlquist (2000) find that the forward puzzle disappears for many emerging economies. Using forward market data for emerging markets, Frankel and Poonawala (2006) analyze the forward premium bias explicitly for developed and emerging market

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economies and document that forward premium bias is less severe in emerging markets. Ferreira and León-Ledesma (2007) find evidence of interest rate in a sample of industrialized and emerging economies applying nonlinear unit root tests, and for OECD countries applying panel unit root tests with structural changes, respectively. Mansori (2003) explores whether the introduction of euro and the adoption of accession partnerships with the EU have an effect on the UIP condition for the Central European economies. His findings suggest that the UIP condition holds for the period 1994–2002, and the analyzed structural breaks seem to matter. Dickinson and Mullineux (2001) provide an overview of financial integration between the CEE countries and point out that most of those countries' monetary and exchange rate policy on financial markets increase convergence of the financial systems with the EU.

Since the collapse of the Bretton Woods system, the global integration of the financial and goods market has increasingly become to be a most significant and profound phenomenon in the world economy. Consequently, the global financial markets have gradually been linked and therefore an integrated international capital market is forming. From the theoretical view, in a one-world market, because of the free capital allocation of the investors, the arbitrage occasions can be reduced. With the development of the interdependence among national markets, the country-specific interest rate spread should exhibit a convergence trend in the long run. Such complete convergence is known as the UIP hypothesis. If the UIP holds, that means a no-arbitrage condition between investing in a domestic currency denominated asset and a foreign currency denominated asset. One individual country could not pursue an independent monetary policy, thus, the country may lose the power to influence the real economy. In an open and effective financial market, the interest rate differentials between two countries may cause international capital flows, and then may induce the change of exchange rate. The arbitrage space will decrease due to the change of exchange rate, until the financial market returns to the equilibrium status (Merlevede et al., 2003; Obstfeld and Rogoff, 1995). Otherwise, the violation of the UIP indicates that capital markets are not efficient and there is a possibility of arbitrage opportunity (Cook, 2009). In this study, we analyze whether UIP holds in CEE countries due to their increasing importance in view of joining with the EU or EMU. The economic transition features of CEE countries provide an interesting study of UIP hypothesis test. First, there were centrally planned and fast liberalization to prices and markets, and some suffered from high inflation. Second, and most of all, the initial conditions for CEE countries' transition varied extensively and they may be an important indicator in explaining the magnitude of deviations from UIP. The issue of monetary policy coordination is important for the European Monetary System. It is the reason that policy coordination and the resulting monetary policy convergence would be necessary for successfully enlarging the Euro currency area. Hence, empirical evidence regarding the state of monetary policy convergence will be helpful for political decision makers.

In particular some research was done on the field of measuring the impact of international business cycle to small open economy; see Smith and Summers (2005), Artis et al. (2007), and Chen and Shen (2007). Also purchasing power parity hypothesis was considered on the field of nonlinear cointegration approach; see Sarno et al. (2004) and Peel and Venetis (2005). Some authors revisited very fundamental and old money-output causality hypothesis and provided empirical testing on the basis of nonlinear models; see Escribano (2004), Haug and Tam (2007), Seo (2006), and Kapetanios et al. (2006). Empirical evidence on the stationary of the interest and exchange rate convergence is abundant, but unfortunately, thus far, there are none conclusive. For previous studies, one possible explanation for the inconsistencies in the existing empirical evidence on the UIP hypothesis is that the prior studies implicitly assume that interest and exchange rate behavior is inherently linear in nature. It is well known that if interest and exchange rate differential follows a nonlinear stationary process then tests based on linear models such as the widely used augmented Dickey–Fuller (ADF) unit root models will be mis-specified (Chortareas et al., 2002). However, Sonora and Tica (2010) also demonstrate that the adoption of linear stationarity tests is inappropriate for the detection of mean reversion if the true process of the data generation of the interest rate is in fact a stationary non-linear process. The presence of nonlinear mean-reverting adjustment has been advanced by recent theoretical developments that emphasize the role of transaction costs, imperfect capital mobility and incomplete institutional reforms. An alternative view is that nonlinearity at the aggregate level is caused by other influences, such as the effects of official interest and exchange rate intervention. Additionally, the existence of structural changes in the UIP might imply broken deterministic time trends and the result is a nonlinear pattern (Cuestas and Harrison, 2010).

This study contributes significantly to this field of research because, first of all, we examine evidence for UIP for CEE countries, using the threshold autoregressive model (TAR) and the test statistics suggested by Caner and Hansen (2001). The main advantage of this procedure is that it allows one to simultaneously test for nonlinearities and nonstationarity. Secondly, to the best of our knowledge, this study is the first of its kind to utilize the threshold unit root test for long-run UIP in CEE countries. This empirical result provides strong evidence favoring the validity of UIP for the 7 CEE countries being studied. This useful information is important that it reveals how participants in financial markets assess the convergence status of the CEE countries. Costs and benefits of EMU enlargement will depend inter alia on financial markets' confidence in the proper selection of new EMU members, and public confidence is reflected in convergence of interest rates and exchange rate stability. Moreover, it describes monetary convergence and monetary policy strategies of the European integration process.

The remainder of this study is organized as follows. Section 2 describes the UIP theory and methodology of the non-linear threshold unit root test. Section 3 presents the data used in our study and discusses the empirical findings. Finally, Section 4 reviews the conclusions we draw.

2. The theory of uncovered interest parity & threshold unit-root test methodology

The UIP theory states that the interest rate differential between two countries has to equal the expected change in the exchange rate (Krugman and Obstfeld, 2003). Denote the domestic nominal interest rate per annum in period t by i_t, the corresponding interest rate of the reference country by i_t^*, and the exchange rate in terms of domestic currency per reference currency by S_t, then UIP can be written as:

$$i_t - i_t^* = \frac{S_{t+k}^e - S_t}{S_t} \tag{1}$$

where k is the maturity related to the exchange rates, and superscript e indicates expected values. Domestic and foreign interest rates have to be identical with respect to maturity, uncertainty, default probability etc. of the corresponding asset. According to UIP, a higher domestic interest rate indicates an expected devaluation of the domestic currency while a lower domestic rate than the reference interest rate indicates an expected appreciation of the domestic currency.

However, this strict form of UIP can only be expected to hold, if foreign and domestic currencies are perfect substitutes. This is rather seldom the case such that the relation has to be augmented by a country-specific and possibly time varying risk premium λ_t:

$$\lambda_t = (i_t - i_t^*) - \frac{S_{t+k}^e - S_t}{S_t}. \tag{2}$$

The risk premium is positive if the domestic interest rate is higher than UIP predicts. The time path of λ_t can ex post be interpreted as an

indicator for the substitutability of domestic and reference currency by replacing the expected exchange rate change with the ex post observed exchange rate change. If a systematically positive or negative risk premium exists, the two currencies are not yet close substitutes, which indicates that monetary integration has not been achieved yet. On the other hand, if the risk premium fluctuates with low or diminishing variance around zero, domestic and reference currency are accepted as close substitutes which may be interpreted as evidence in favor of economic integration. When reaching monetary integration, this risk premium should disappear such that the development of the risk premium can be interpreted as a measure of monetary integration.

According to Wolters (2002), the UIP theory implies that the λ_t is a stationary process, that is, the two spreads and the difference between the long-term interest rates of different countries should be stationary. This implies that we can represent λ_t in Vector Autoregressive (VAR) form as follows:

$$\lambda_t = c_0 + c_1\lambda_{t-1} + \varepsilon_t \tag{3}$$

which can be represented as

$$\Delta\lambda_t = \theta_0 + \theta_1\lambda_{t-1} + \sum_{i=2}^{p}\beta_i\Delta\lambda_{t-i+1} + \varepsilon_t. \tag{4}$$

Now for UIP to hold empirically, we need to test $H_0 : \theta_1 = 0$ vs. $H_1 : \theta_1 < 0$, which we do by testing for unit roots in the λ_{t-1}. Note that we allow $\theta_0 \neq 0$, since different countries may have different risk premium (Ferreira and León-Ledesma, 2007). In order to test UIP in the CEE countries, we apply the threshold effect on the unit root process of the risk premium series λ_t using the threshold unit root model developed by Caner and Hansen (2001), who consider a two regime TAR (k) model:

$$\Delta\lambda_t = \theta'_1 x_{t-1} I_{\{Z_t \le \omega\}} + \theta'_2 x_{t-1} I_{\{Z_t > \omega\}} + e_t, \quad t = 1, \ldots, T \tag{5}$$

where $x_{t-1} = \left(\lambda_{t-1}, \; v'_t, \; \Delta\lambda_{t-1}, \ldots, \Delta\lambda_{t-k}\right)'$; v_t is a vector of exogenous variables including an intercept and possibly a linear time trend; $I_{\{\cdot\}}$ is the indicator function and equal to 1 only if the certain condition in curly braces is true; e_t is an *i.i.d.* disturbance; $Z_t = \lambda_{t-1} - \lambda_{t-m}$ for some $m \geq 2$ is the threshold variable; ω is a threshold parameter and takes on values in the interval $\omega \in \Lambda = [\omega_1, \omega_2]$; $k \geq 1$ is the autoregressive unit root. The components of θ_1 and θ_2 can be partitioned as follows:

$$\theta_1 = \begin{pmatrix} \rho_1 \\ \beta_1 \\ \alpha_1 \end{pmatrix}, \quad \theta_2 = \begin{pmatrix} \rho_2 \\ \beta_2 \\ \alpha_2 \end{pmatrix}$$

where ρ_1 and ρ_2 are scalar terms. β_1 and β_2 have the same dimensions as v_t, and α_1 and α_2 are k-vectors. Thus (ρ_1, ρ_2) are the slope coefficients on λ_{t-1}, (β_1, β_2) are the slopes on the deterministic components, and (α_1, α_2) are the slope coefficients on $(\Delta\lambda_{t-1}, \ldots, \Delta\lambda_{t-k})$ in the two regimes.

The threshold effect in Eq. (5) has the null hypothesis $H_0 : \theta_1 = \theta_2$, which is tested using the familiar Wald statistic: $W_T = W_T(\hat{\omega}) = \sup_{\lambda\in\Lambda} W_T(\omega)$. The stationarity of the process ω_t can be established in two ways. First, when there is a unit root in both regimes. Here the null hypothesis is of the form $H_0 : \rho_1 = \rho_2 = 0$, which is tested against the unrestricted alternative $\rho_1 \neq 0$ or $\rho_2 \neq 0$ using the Wald statistic. The parameters ρ_1 and ρ_2 of Eq. (5) control the regime-dependent unit root process of the risk premium. If $\rho_1 = \rho_2 = 0$ holds, the risk premium has a unit root that can be described as a rejection of UIP. This statistic is:

$$R_{2T} = t_1^2 + t_2^2 \tag{6}$$

where t_1 and t_2 are the t ratios for $\hat{\rho}_1$ and $\hat{\rho}_2$ from the ordinary least squares estimation. However, Caner and Hansen (2001) claim that this two-sided Wald statistic may have less power than a one-sided version of the test. As a result, they propose the following one-sided Wald statistic as follows:

$$R_{1T} = t_1^2 I_{\{\hat{\rho}_1 < 0\}} + t_2^2 I_{\{\hat{\rho}_1 < 0\}}. \tag{7}$$

R_{1T} tests H_0 against the one-sided alternative $\rho_1 < 0$ or $\rho_2 < 0$. Caner and Hansen (2001) show that both tests R_{1T} and R_{2T} will have power against both alternatives.

3. Data and empirical results

We use monthly data that covers from 1997 to 2011 to apply the Caner and Hansen (2001) threshold unit test in testing the validity of UIP. During this period, CEE countries started their liberalization programs and transited to market economies. The data of our empirical study consists of the 10 CEE countries: including Belarus, Bulgaria, Croatia, Czech Republic, Hungary, Latvia, Macedonia, Poland, Romania and Russia Fed. For interest rate, we use money market rate or deposit rate, specifically, Belarus (weighted average rate offered by banks on deposits in national currency), Hungary (simple arithmetic rate offered by banks on deposits), Macedonia (lowest rate on household deposits), Bulgaria (LEONIA reference rate), Czech Republic (money market rate), Latvia (weighted average rate on overnight loans in national currency transacted in the interbank market), Poland (money market rate), Romania (daily average rate on deposits between commercial banks in national currency), the Russian Fed (money market rate), Croatia (short-term rate determined on the Zagreb Money Market), and EU (money Market Rate). For exchange rate, we use end of period spot price of domestic currency in units of euro. All the interest rate and exchange rate data is taken from the International Monetary Fund's International Financial Statistics and the OECD Main Economic Indicators database. We have then computed the risk premium for 10 CEE countries against the EU. In addition, we implement our empirical procedures in Matlab software R2011b.

First, we use Wald test W_T to examine whether or not we can reject the linear autoregressive model in favor of a threshold model. The results of Wald test in Table 1, and also report the bootstrap critical values generated at conventional levels of significance. The bootstrap p-value for threshold variables of the form $Z_t = \lambda_{t-1} - \lambda_{t-m}$ for delay parameter m is ranged from 2 to 12. The parameter m is generally unknown; there is no reason to think the optimal delay parameter will be the same across countries. To circumvent this, Caner and Hansen (2001) suggest making m endogenous by selecting the least squares estimate of m that minimizes the residual variance. This amounts to selecting m at the value that maximizes the W_T statistic. Taken together, these results imply strong statistical evidence against the null hypothesis of linearity at least 10% in nine CEE countries except Macedonia with a p-value of 0.826, indicating that there is threshold effect and thus simple linear models are inappropriate. Subsequently, non-linear threshold autoregressive models are our preferred models.

Next, we explore the threshold unit root properties of risk premium based on R_{1T} statistic for each delay parameter m, ranging from 2 to 12, paying particular attention to the results obtained for our preferred model. The R_{1T} test results, together with the bootstrap critical value at the conventional levels of significance and the bootstrap p-value, are reported in Table 2. We are able to reject the unit root null hypothesis for Hungary, Poland, Romania and the Russian Federation at the 1% level; for Croatia at the 5% level; and for Bulgaria and Czech Republic at the 10% level. However, we are unable to reject the threshold unit root hypothesis for the other three CEE countries, Belarus with a p-value of 0.634, Latvia with a p-value of 0.290 and Macedonia with a p-value of 0.402. As for these three countries, this finding may be attributed to the influence of capital controls and other inefficiencies related to the underdevelopment of the financial

Table 1
Threshold test.

Country	m	W_T	Bootstrap critical values (%)			Bootstrap p-value	Threshold
			10	5	1		
Belarus	6	148.985	50.427	59.419	85.847	0.000	2.198
Bulgaria	9	121.457	50.926	57.471	72.538	0.000	0.322
Croatia	11	93.641	48.342	52.746	58.630	0.000	2.548
Czech Republic	5	44.937	40.219	43.681	46.908	0.078	0.277
Hungary	9	70.609	58.815	64.864	84.009	0.036	1.322
Latvia	5	181.066	171.157	208.501	268.442	0.088	1.689
Macedonia, FYR	12	26.664	56.777	58.353	71.064	0.826	0.636
Poland	2	47.286	39.619	42.012	50.116	0.018	−0.719
Romania	10	105.703	46.127	50.701	59.892	0.000	−7.014
Russian Federation	9	115.695	48.411	55.122	71.943	0.000	1.885

sector and transaction cost. As we know, these three countries still had significant restrictions on foreign exchange transactions and face high inflation. For example, in Belarus, the debate between central bank and government about exchange rate intervention, the inflation target and the effect of fiscal policy on inflation lead to increasing uncertainty about the future development. The monetary authorities in Latvia implemented a free-floating exchange rate regime for its currency and changed its monetary policy regime to inflation targeting. It seems that the inflation problems and exchange rate instability problems in Latvia have not allowed converging. The social instability and economic recession result in capital dramatically flowing out of Macedonia, with the addition of high inflation pressure, both increase risks and costs to their economic and financial system. Just as we mentioned earlier, rejecting the UIP implies that their interest rates exhibit more instability, and in the long-run, interest rate differentials remain sizable and international capital mobility remains incomplete. Consequently, compared with the present participants in European Economic and Monetary Union, the money markets of these three countries still show distinct deficits in integration. So it is worth noting that for these three countries only if they adopt more efficient monetary and fiscal tools to promote price stability and economic growth, as well as reduce transaction regulations and government intervention, their economic and financial environment would be more stable and stationary and the distinct deficits in integration would be smaller.

In the other sides, the non-linear threshold unit-root test employed by Caner and Hansen (2001) in this study provides strong evidence favoring the long-run validity of UIP for the 7 CEE countries being studied. Of course, it should be pointed out here that due to using different data and empirical tests, the conclusions whether the UIP holds and long-term interest rate converges in CEE countries are different. However, it is these debates that stimulate us applying different methods to study this topic. So next, we would give the possible reasons why the UIP holds and long-term interest rate converges in the seven CEE countries. We find that, most of these countries managed to reduce the excessive fiscal deficits of the 1990s, have kept inflation under control, and have reduced the debt-to-GDP ratio and been a significant reduction in discrepancies. For example, following the 1997 economic and financial crisis, Bulgaria adopted a euro-based currency board to stabilize its exchange rate, and implemented a comprehensive economic plan, which included trade and price liberalization, social sector reform, and divesting in state-owned enterprises. The Czech Republic has adopted a monetary policy regime of inflation targeting since 1998, which allowed the country to fight inflation successfully. Also, the existing managed floating exchange rate regime is fully compatible with the EU membership. Similarly since 2000, Romania has implemented tight fiscal and monetary policies along with structural reforms designed to support growth and improve financial discipline in the private sector. These reforms have placed the country's public finances and the financial system in a firmer footing. Further, Romania is currently considering a currency board vis-à-vis the euro, in order to reduce inflation and gain monetary policy credibility. The monetary authorities in the Russian Federation implemented a free-floating exchange rate regime for its currency and changed its monetary policy regime to inflation targeting. Taken together our results provide strong support for UIP for seven CEE countries and point that these countries are non-linearly stationary, implying that deviations of risk premium convergence are mean reverting towards the UIP equilibrium. As mentioned earlier, the CEE countries faced the second stage of economic transition in the aftermath of the collapse of socialism; the establishment of Euroland at the turn of the century. This study investigates the market mechanisms in the early nineties and establishment and enlargement of Euroland acted on risk premium convergence. These CEE transition countries performed a wide range of market based reforms during 20 years, removing obstacles to capital mobility, reducing risk premiums and performing institutional reforms. Obviously, such an environment provides interesting opportunity to estimate effects of reforms on the risk premium convergence, as well as interventions in the monetary markets, which could be behind this nonlinear behavior.

Table 2
Threshold unit root test.

Country	R_{1T}	Bootstrap critical values (%)			Bootstrap p-value
		10	5	1	
Belarus	2.887	11.787	15.129	24.662	0.634
Bulgaria	12.309	10.309	13.070	20.148	0.070
Croatia	15.771	11.942	15.446	25.417	0.046
Czech Republic	10.576	9.603	12.487	18.109	0.092
Hungary	43.873	16.545	20.734	33.3052	0.006
Latvia	6.855	11.690	15.772	23.957	0.290
Macedonia, FYR	5.781	14.072	18.147	29.686	0.402
Poland	20.558	10.662	12.722	17.078	0.006
Romania	64.407	11.493	13.835	24.596	0.000
Russian Federation	66.460	13.012	15.971	21.069	0.000

The validity of UIP is important to policy makers in seven CEE countries who base their determination on interest and exchange rate adjustments. The result means that the unbounded gains from arbitrage in traded portfolios are impossible among these seven countries. It also means that we can use UIP to test whether national risk premiums were bound to converge; the scope for international portfolio diversification would be significantly reduced; and national monetary policy as a tool of effective macro-management would be restricted to the degree it affects the international interest and exchange rate (Mark, 1985). The implication of UIP holds that assets of these seven CEE countries with identical risk, liquidity and maturity characteristics offer the same expected return across different countries. The extent to which UIP holds therefore serves as indicator of the degree of product and financial market integration. This might be important for several reasons and ever since Grubel (1968) it has been well known that diversifying a portfolio along international lines might improve the portfolio's risk-return characteristics. If all

other things are equal, international portfolio diversification in these seven CEE countries will be most attractive to investors when there are differences in interest and exchange rates across countries. Meanwhile, the extent of product market integration in CEE countries might provide useful information for countries seeking to join the EU monetary union. Moreover, the validity of UIP is practical to policy makers in CEE countries to evaluate their preparedness and maturity to join the EMU.

4. Conclusion

In this empirical study, we assess the non-stationary properties of the UIP with risk premium for 10 CEE countries by applying non-linear threshold unit-root test, which has higher power than the linear method if the true data generating process of the risk premium is in fact a stationary non-linear process. This study examined the validity of UIP from the non-linear point of view and the findings provide robust empirical evidence supporting the validity of the long-run UIP, suggesting to seven countries that their interest and exchange rate adjustments are mean reversion towards UIP equilibrium values in a non-linear way. It implies that transaction costs may be affecting the portfolio decisions of the international investors. This might offer an alternative explanation for what the researchers have encountered in explaining the unit root hypothesis for interest and exchange rate convergence.

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